Idaho Wildfire Emissions Estimates

2021 Wildfire Season

State of Idaho

Department of Environmental Quality

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Abbreviations, Acronyms, and Symbols

CO	carbon monoxide
DEQ	Idaho Department of Environmental Quality
EPA	United States Environmental Protection Agency
FCCS	Fuel Characteristic Classification System
FFT	Fuel and Fire Tools
IRWIN	Integrated Reporting of Wildland-Fire Information Project
MTRI	Michigan Tech Research Institute
NIFC	National Interagency Fire Center
NO_X	nitrogen oxides
$PM_{2.5}$	Particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers, also known as fine particulate matter
USFS	United States Forest Service
VOC	volatile organic compounds
WFEIS	Wildland Fire Emissions Inventory System
WFIGS	Wildland Fire Interagency Geospatial Services

Executive Summary

Every year wildfires consume hundreds of thousands of acres of land across Idaho and millions more throughout the western United States. These fires are one of the largest sources of many air pollutants including carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), oxides of nitrogen (NO_X), and volatile organic compounds (VOC). Emissions of these pollutants into the air vary from year-to-year based on the number, size, and location of the wildfires. Estimating emissions from wildfires is a rapidly advancing science, and there is much uncertainty involved. The Idaho Department of Environmental Quality's (DEQ's) annual estimates are based on the latest methods and scientific literature on wildfire emission factors and estimation. DEQ has made every effort to provide the best estimates of air pollutant emissions from wildfire in a timely manner using the tools available. These estimates may vary from other works based on either more simplified or more detailed methods.

The 2021 wildfire season in Idaho saw an increase in acreage burned compared to 2020. A total of 431,129 acres were consumed by wildfire in Idaho. The total acreage is below the 10-year average of around 600,000 acres. Despite this relatively low acreage year, wildfires in Idaho in 2021 still released nearly 100,000 metric tons of $PM_{2.5}$ and 600,000 metric tons of CO gas. Additionally, over 7,500 metric tons of NO_X and almost 150,000 metric tons of VOC (the two main ozone precursor pollutants) were emitted into the atmosphere. Wildfires are estimated to have represented the single largest source of CO, VOC, and $PM_{2.5}$ in Idaho in 2021.

DEQ's *2021: Idaho's Year in Wildfire* provides an overview of historical burned areas, emissions, and air quality.

1 Introduction

Wildfires are an annual occurrence in the western United States and generally occur in Idaho from mid-summer to early autumn. In an average season, Western US states (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) experience approximately 5 million acres of wildfires (NIFC 2021a). In addition to the immediate, direct danger, wildfires have the potential to negatively impact the air quality in downwind communities for extended periods. Wildfire smoke can settle into communities for days to weeks at a time, resulting in an increased risk for a variety of acute and chronic health impacts in the affected population.

Hundreds of different chemicals are present in wildfire smoke, including large amounts of the federal Clean Air Act-regulated criteria air pollutants carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), oxides of nitrogen (NO_X), and volatile organic compounds (VOC). In Idaho, wildfires are often among the largest sources of these pollutants. While wildfires generally do not impact a community's compliance with the National Ambient Air Quality Standards because under an US Environmental Protection Agency (EPA) rule they can be classified as "exceptional events," it is valuable to assess the magnitude of wildfire emissions for planning purposes and to evaluate the potential for health impacts in affected areas. This report provides a reasonable and timely estimate of the total emissions of CO, $PM_{2.5}$, NO_X, and VOC from Idaho wildfires in 2021 and compares these estimates to previous years and to other major sources of air pollutants.

DEQ's *2021: Idaho's Year in Wildfire* provides an overview of historical burned areas, emissions, and air quality.

2 Methods

Wildfire emissions estimation is a constantly evolving science, and there are many valid approaches ranging from very simple to highly complex. The Idaho Department of Environmental Quality's (DEQ's) approach uses a compromise between accuracy and timeliness.

2.1 Tools

The Michigan Tech Research Institute (MTRI) developed the Wildland Fire Emissions Inventory System (WFEIS) online tool that combines user input fire boundaries and modeled fuel moisture values with the US Forest Service's (USFS) Fuel and Fire Tools (FFT) suite of tools (French et al. 2014). This program allows users to estimate fire emissions rapidly and relatively accurately. The FFT combines several tools from the USFS including the Fire Emissions Production Simulator, Consume model, and Fuel Characteristic Classification System (FCCS) into one tool that can accurately estimate emissions from wildland fires (FERA 2021). The FFT uses fuels data classified into fuelbeds, environmental variables, and fire weather information to calculate fire

behavior, fuel consumption, heat release, and pollutant emissions for a variety of chemical species. This system is the most comprehensive and up-to-date method for estimating wildfire emissions and a significant improvement to previous efforts by DEQ to estimate year-end wildfire emissions.

2.2 Geographic Information

The most complete wildfire perimeter database is available from the National Interagency Fire Center (NIFC) through the Wildland Fire Interagency Geospatial Services (WFIGS) Group (NIFC 2021b). While absolute perimeters for each fire are only available from the unit managing each fire, this database contains the most readily available and sufficiently complete and accurate set of wildland fire perimeters. NIFC uses the same data to develop its year-end statistics on wildland fires. The data is developed through the Integrated Reporting of Wildland-Fire Information (IRWIN) project (Forests and Rangelands 2019). IRWIN is managed by the Forests and Rangelands joint partnership between the US Department of Interior and US Department of Agriculture. The goal of IRWIN is to enable end-to-end fire reporting capability by consolidating data entered into existing applications used to manage wildland fire incidents. A unique record is developed for every wildland fire incident and is based on input from incident reports, global positioning system data, and infrared imagery from fixed-wing aircraft and satellite platforms.

DEQ downloaded the most recent perimeters of all 2021 wildfires from the NIFC website in ArcGIS geodatabase format on December 6, 2021. The database, WFIGS-2021 Wildland Fire Perimeters to Date, contained one perimeter for each fire covering all areas burned by that fire and does not overlap with previously burned areas. The database should include all wildfires for 2021 to-date, but it is a working database that will not be finalized until spring/summer 2022. Spot review and quality assurance check were performed to ensure that each perimeter represented an individual fire and that there were no duplicates. Two duplicates were found and removed. The final dataset includes 439 individual wildfires ranging from just a few hundred square feet to over 90,000 acres from the Shovel Creek fire south of Lewiston, for a total of 431,129 acres.

2.3 Calculations

The year-to-date wildfire perimeters were uploaded to the WFEIS in shapefile format using the user submission option in the calculator. The Fire Discovery Date from IRWIN was used as the fire date for each fire. Fuel moisture options were left as the defaults, including modeled values based on the burn location and day for 1,000-hour fuel, duff, and litter. The FCCS fuelbed system was used for the fuel loadings with default canopy consumption values for each fuelbed. Blackened shrub was left at the default value of 50%.

3 Results

The WFEIS emission calculations were exported in spreadsheet format aggregated by burned area and separately aggregated by fuelbed. The spreadsheet summarizes emissions by pollutant for each fire and also for each fuelbed, which allows an analysis of emissions by vegetation type.

3.1 Total Wildfire Emissions

The 2021 season saw a nearly 50% increase in acreage burned compared to 2020 with 431,129 acres consumed by wildfire in Idaho compared to just over 300,000 in 2020. This number is still well below the 2011–2020 average of 601,826 acres. Despite this relatively low acreage year, wildfires in Idaho still released nearly 100,000 tons of $PM_{2.5}$ and 600,000 tons of CO gas. Additionally, over 7,500 tons of NO_X and almost 150,000 tons of VOC (the two main ozone precursor pollutants) were emitted into the atmosphere. Nonmethane organic compounds are used as a surrogate for VOC. This data is summarized in Table 1.

Table 1. Estimated air pollutant emissions for all Idaho wildfires in 2021.

	$PM_{2.5}$	CO	NOx	VOC
Total emissions (metric tons)	89,633.61	592,771.50	7,500.34	142,365.33

3.2 Emissions by Vegetation Type

The WFEIS also provides outputs of fuelbed types burned. Analyzing the vegetation types that were burned by wildfires can provide some context for comparison between years as emissions vary amongst the different types. DEQ combined the detailed FCCS vegetation types output from WFEIS into five broad categories to simplify the reporting. All *forest* vegetation types are included in the "timber" category; the *grassland* vegetation types are combined as "grassland;" the *shrubland* types are combined as "shrubland;" and all managed croplands including trees, grasses, and row crops are combined as "cropland." All "other" categories that represent mostly urban areas, barren land, and snow/ice/water are combined. The vegetation types for all areas burned are summarized in Table 2 while the detailed FCCS fuelbed types are included in Appendix A.

Table 2. 2021 wildfire areas by vegetation type.

Vegetation Type	Area (acres)	Total Area (%)
Timber	271,055.73	62.9
Shrubland	51,291.95	11.9
Grassland	92,818.83	21.5
Cropland	2,934.86	0.7
Other	13,027.10	3.0
Totals	431,128.47	100

The vast majority of all emissions came from wildfires that burned timber vegetation types. Timber tends to have much higher fuel loadings than the other vegetation types. Timber also

represented nearly two-thirds of all land burned by wildfire in 2021. No emissions are reported for "Other" vegetation types as this includes land cover types that do not burn (e.g., water and barren land) and other land cover types that do not have good estimates of consumption, fuel loading, or emission factors such as urban areas. Total wildfire emissions by vegetation type are summarized in Table 3 and Figure 1.

Table 3. Estimated air pollutant emissions in metric tons for all Idaho wildfires in 2021.

Vegetation Type	Acres Burned	$PM_{2.5}$	CO	NOx	VOC
Timber	271,055.73	87,900.82	581,552.85	6,883.49	138,860.53
Shrubland	51,291.95	1,015.40	8,917.58	420.77	2,399.25
Grassland	92,818.83	665.87	2,135.83	182.01	1,026.17
Cropland	2,934.86	51.53	165.29	14.08	79.40
Other	13,027.10	0.00	0.00	0.00	0.00
Totals	431,128.47	89,633.61	592,771.50	7,500.34	142,365.33

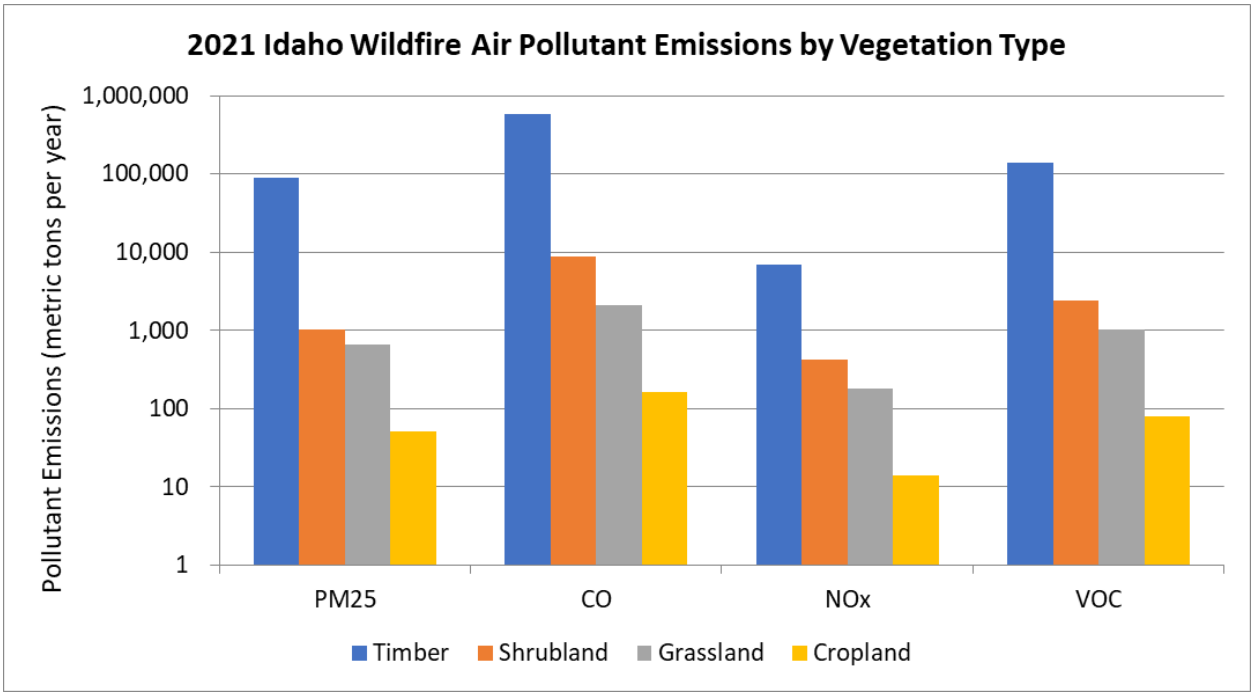

Figure 1. 2021 Idaho wildfire air pollutant emissions by vegetation type.

Note that the vertical axis is using a logarithmic scale as the emissions from shrublands, grasslands, and croplands were so much smaller than those from timber that they were not visible using a normal scale.

3.2.1 Comparison to Previous Years

Wildfire emissions can vary significantly from year-to-year depending on numerous factors including the number of acres burned, vegetation types burned, and fuel moisture content. A comparison of the 2021 emissions to previous years is provided in Figure 2. Emissions in 2021 were about average for the past 10 years and a 32%–39% increase from 2020 depending on pollutant. Historic fire emissions were also calculated in WFEIS using the same default

emissions/consumption inputs used for the 2021 calculations. The historic wildfire perimeters are also from WFIGS and are available within the WFEIS tool (labeled NIFS perimeters).

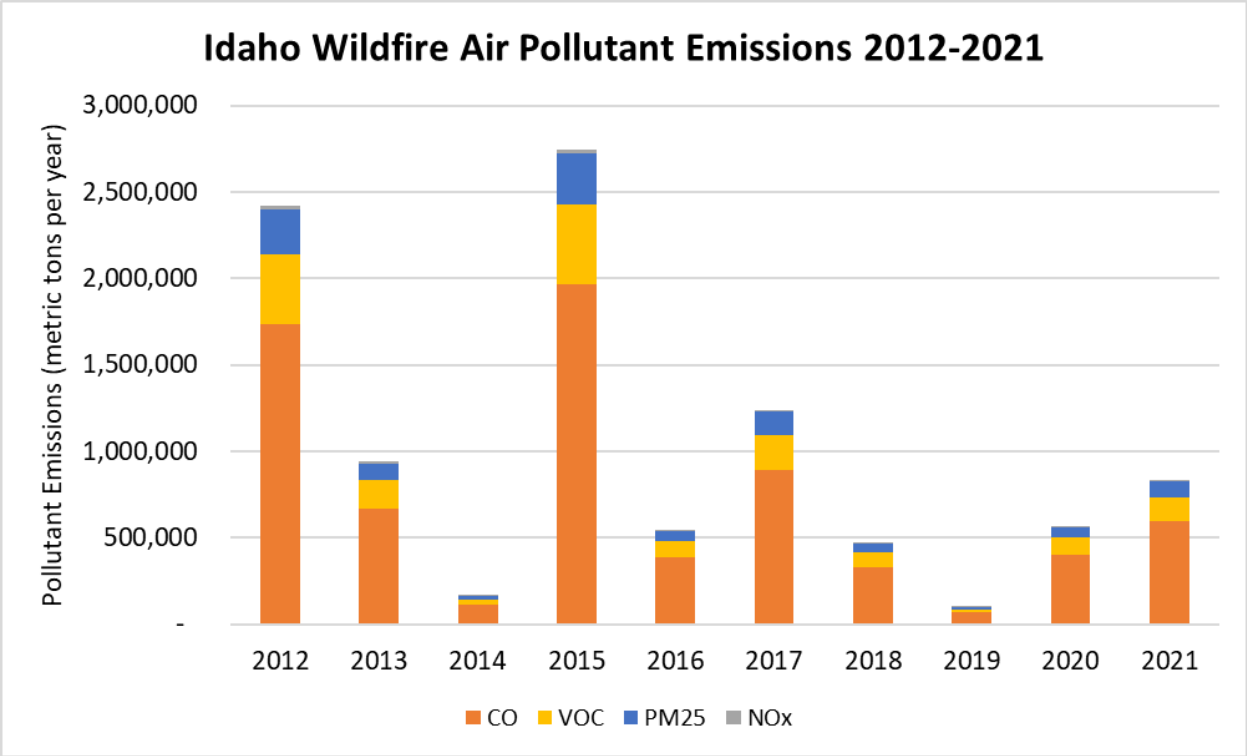

Figure 2. Idaho wildfire air pollutant emissions by year from 2012–2021 as calculated by the WFEIS.

3.2.2 Comparison to Other Sources

Wildfire emissions represent one of the single largest sources of air pollutants in Idaho. Table 4 and Figure 3 compare 2021 wildfire emissions to the other large sources of air pollutants in Idaho, which include industrial sources, onroad mobile sources (cars and trucks), and nonroad mobile sources (e.g., construction equipment, recreational equipment, and airport support equipment). The industrial, onroad mobile, and nonroad mobile data were compiled for submittal to EPA for the 2017 National Emissions Inventory and are the most recently available data for these categories (NEI 2017). Emissions from these categories do not change significantly from year-to-year.

As shown in Figure 3, wildfires were the largest individual source of CO, VOC, and $PM_{2.5}$ in Idaho in 2021, emitting orders of magnitude more of these pollutants than any other source. Wildfires in 2021 emitted more of each of these pollutants into the air than all industrial, onroad mobile, and nonroad mobile sources in the entire state combined including more than twenty times as much $PM_{2.5}$, more than five times as much VOC, and almost three times as much CO gas.

Table 4. 2021 Idaho wildfire emissions compared to other large sources in metric tons per year.

Source	$PM_{2.5}$	CO	NOx	VOC
2021 Wildfires	89,633.61	592,771.50	7.500.34	142,365.33
2017 Industrial Sources	980.67	11,000.54	6,800.26	1,506.84
2017 Onroad Mobile Sources	2,718.68	131,034.65	35,513.99	15,717.62
2017 Nonroad Mobile Sources	723.70	75,495.76	7,009.38	9,939.36

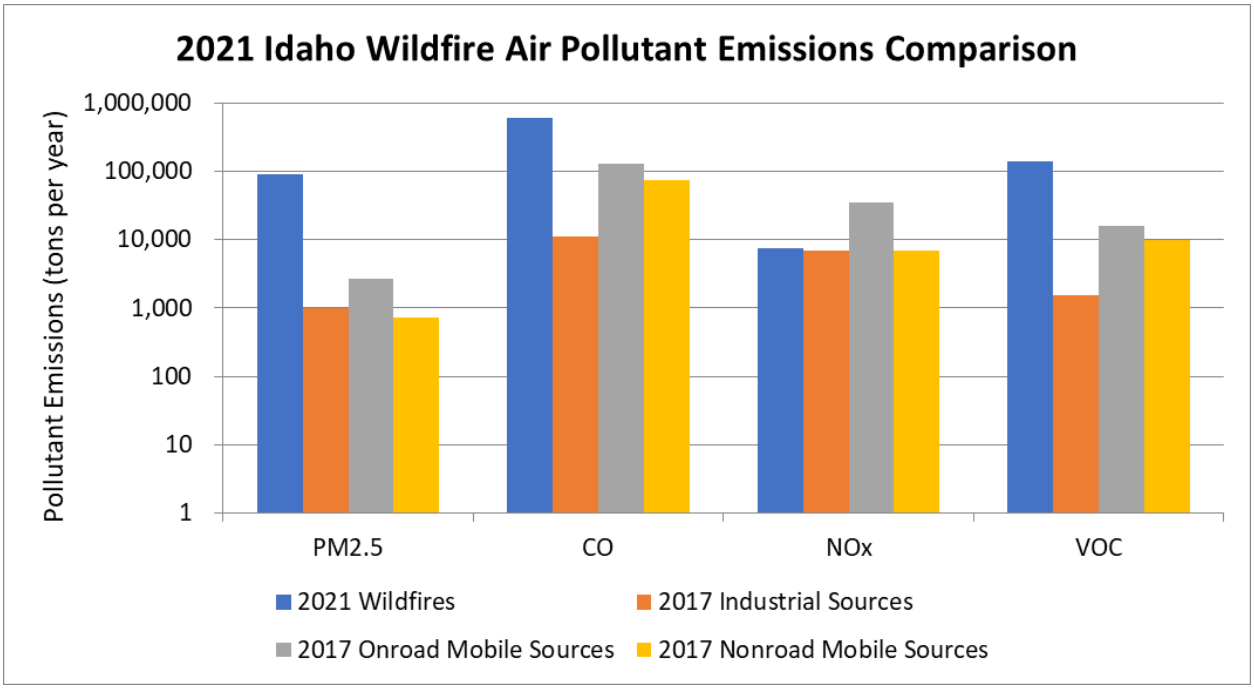

Figure 3. 2021 Idaho wildfire air pollutant emissions compared to other large sources.

Note that the vertical axis is using a logarithmic scale as the emissions from anthropogenic sources were so much smaller than those from wildfire that they were not visible using a normal scale.

4 Conclusions

The 2021 wildfire season in Idaho was below average in terms of acres burned with approximately 431,128 acres affected by wildfire. DEQ used the WFEIS developed by the MTRI to estimate the air pollutant emissions from these wildfires. This tool is based on the latest research on wildfire emissions and is a significant improvement from previous efforts by DEQ to estimate year-end wildfire emissions. The results from this tool indicate that despite the below average acreage burned, wildfires in Idaho were still the single largest source of $PM_{2.5}$, CO, and VOC in the state in 2021.

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Appendix A. Detailed FCCS Fuelbed Types Within Wildfire Perimeters

Table A-1. FCCS fuelbed types within 2021 wildfire burned areas in Idaho as calculated by the Wildland Fire Emissions Inventory System (WFEIS).

FCCS ID	FCCS Fuelbed	DEQ Grouping	Area (acres)	Total Area (%)
1261	Fallow field - growing season	Cropland	223.63	0.05
1244	Other crop fields - post harvest	Cropland	756.39	0.18
1281	Pasture, hay, or alfalfa field - grazed or harvested	Cropland	993.85	0.23
1273	Tree fruit field - no inter-row groundcover	Cropland	0.25	0.00
1223	Wheat field - post harvest	Cropland	960.74	0.22
66	Bluebunch wheatgrass-bluegrass grassland	Grassland	1,152.00	0.27
318	Bluejoint reedgrass-water sedge grassland	Grassland	133.68	0.03
41	Idaho fescue-bluebunch wheatgrass grassland	Grassland	40,084.29	9.30
235	Idaho fescue-bluebunch wheatgrass grassland - postfire	Grassland	889.08	0.21
435	Little bluestem-buffalograss grassland	Grassland	13.10	0.00
315	Showy sedge-black alpine sedge grassland	Grassland	10,368.01	2.40
236	Tobosa-grama grassland	Grassland	4.20	0.00
57	Wheatgrass-cheatgrass grassland	Grassland	23,063.49	5.35
213	Wheatgrass-cheatgrass grassland - post prescribed burn	Grassland	1,833.27	0.43
221	Wheatgrass-ryegrass grassland	Grassland	5,766.68	1.34
302	Willow/sedge grassland	Grassland	9,511.05	2.21
0	Urban/Baren	Other	12,576.38	2.92
900	Water	Other	450.72	0.10
218	Gambel oak/big sagebrush shrubland	Shrubland	0.00	0.00
312	Gambel oak/sagebrush shrubland	Shrubland	89.45	0.02
310	Greasewood shrubland	Shrubland	93.90	0.02
401	Holly-privet shrubland	Shrubland	719.07	0.17
237	Huckleberry-heather shrubland	Shrubland	1.24	0.00
308	Low sagebrush shrubland	Shrubland	2,482.41	0.58
313	Mountain mahogany shrubland	Shrubland	113.42	0.03
307	Paloverde shrubland	Shrubland	53.13	0.01
233	Sagebrush shrubland	Shrubland	681.27	0.16
56	Sagebrush shrubland - exotic species	Shrubland	45,336.24	10.52
311	Saltbush shrubland	Shrubland	1,695.38	0.39
69	Western juniper/sagebrush-bitterbrush shrubland	Shrubland	26.44	0.01
317	Bigtooth maple forest	Timber	39.04	0.01
1	Black cottonwood-Douglas-fir-quaking aspen forest	Timber	18.53	0.00
18	Douglas-fir/oceanspray forest	Timber	7,152.93	1.66
52	Douglas-fir-Pacific ponderosa pine/oceanspray forest	Timber	4,299.37	1.00
287	Eastern white pine-eastern hemlock forest	Timber	54.61	0.01
273	Engelmann spruce-Douglas-fir-white fir-ponderosa pine forest	Timber	22.73	0.01
304	Engelmann spruce-subalpine fir/horsetail forest	Timber	1,960.03	0.45
208	Grand fir-Douglas-fir forest	Timber	1,134.70	0.26

FCCS ID	FCCS Fuelbed	DEQ Grouping	Area (acres)	Total Area (%)
314	Limber pine-bristlecone pine forest	Timber	8.65	0.00
286	Limber pine-ponderosa pine forest	Timber	9.88	0.00
22	Mature lodgepole pine forest	Timber	17,078.13	3.96
53	Pacific ponderosa pine forest	Timber	1,961.02	0.45
24	Pacific ponderosa pine-Douglas-fir forest	Timber	117,718.31	27.30
319	Pacific silver fir-Sitka alder forest	Timber	47.94	0.01
210	Pinyon-Utah juniper woodland	Timber	438.36	0.10
211	Ponderosa pine forest - high density	Timber	1.48	0.00
28	Ponderosa pine savanna	Timber	19,635.16	4.55
27	Ponderosa pine-two needle pinyon-Utah juniper forest	Timber	3.71	0.00
219	Ponderosa pine-white fir/quaking aspen forest	Timber	0.49	0.00
42	Quaking aspen/Engelmann spruce forest	Timber	824.83	0.19
305	Red alder forest	Timber	3,458.72	0.80
427	Red spruce-northern white cedar-tamarack forest	Timber	89.70	0.02
59	Subalpine fir-Engelmann spruce-Douglas-fir-lodgepole pine forest	Timber	60,441.49	14.02
426	Sugarberry/acacia forest	Timber	24.71	0.01
409	Virginia pine-chestnut oak/little bluestem forest	Timber	18.53	0.00
2	Western hemlock-western redcedar-Douglas-fir forest	Timber	26,118.69	6.06
61	Whitebark pine/subalpine fir forest	Timber	8,493.97	1.97